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Protection Branch Report of Test No. 16-65

Investigation of Microbial Contamination Inside
Irradiated and Heated Electronic Components

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Protection Branch Report of Test No. 16-65

Investigation of Microbial Contamination Inside Irradiated and Heated Electronic Components

At the request of N.W. LeVora, Martin Company, Middle River, Maryland, this Laboratory tested some electronic components for internal microbial contamination, that had been previously subjected to various doses of high radiation or to dry heat. These components were tested by Martin Company personnel and found to function satisfactorily after the various treatments. The results of the microbiological tests are the subject of this report.

MATERIALS AND METHODS

A total of 31 electronic components were received and, of these, 22 had been subjected to a radiation or dry heat treatment:

a. Two resistors and two capacitors were exposed to a gamma radiation dose of 10^6 rads. Cobalt 60 was used as the gamma radiation source for this and for the components in b. and c. below.

b. Two resistors and two capacitors were exposed to a gamma radiation dose of 5×10^6 rads.

c. Two resistors and two capacitors were exposed to a gamma radiation dose of 10^7 rads.

d. Four transistors were exposed to a total neutron radiation of 4×10^{14} fluence. This was reported to be equivalent to $1 \times 10^6 \pm 75\%$ rads.

e. Three resistors and three capacitors were exposed to two dry heat cycles one for 40 hours at approximately 149°C and the second for 30 hours at 149°C .

Nine untreated electronic components (four resistors, three capacitors, and two transistors) were used as controls.

The procedure used to test electronic components for internal contamination is as follows. The electronic components, the tools needed to break and grind the components, and fluid thioglycollate medium blanks (sealed with tape) were placed in a closed plastic chamber and exposed to ethylene oxide gas for six hours. Electronic components given different treatments and control or untreated components were tested separately to avoid any possible cross contamination. The ethylene oxide treatment sterilizes the air as well as the exterior of all components, materials, and surfaces in the chamber; however it does not affect microorganisms sealed within the components. After treatment the chamber was aerated 16 hours. Each electronic component was then broken, ground as well as possible, and the pieces put into a fluid thioglycollate medium blank to incubate at 37 C for seven days. An aliquot of each sample blank was then streaked on tryptose agar to check for microbial growth. In addition, a methylene blue stain of the sample was examined microscopically for microorganisms. If no microorganisms were detected, the sample was inoculated with approximately 100 viable bacterial cells, to assure that the medium in the presence of the component was capable of supporting bacterial growth.

RESULTS AND DISCUSSION

Results of testing untreated and radiation or heat treated electronic components for internal contamination are given in Table I. Out of the nine untreated components tested, only one transistor was found to be contaminated internally. This is consistent with the results reported by Phillips and Hoffman ^{1/} and Cordaro and Wynne ^{2/} who found 7-17% of the off-the-shelf components tested to be internally contaminated. Since this percentage is very low and since so few components were treated and tested in the present study, it is difficult to appraise the effect of any given sterilization treatment. When only four or six off-the-shelf items are selected for test it is quite probable that none will be internally contaminated before subjecting to any sterilizing treatment. This probability is greater than that all will be internally contaminated. The difficulty of assessment is evident in the data, where the percentage of contamination was higher (5/22) among the treated components than the untreated (1/9). However, a close examination of the results of the irradiated components reveals that four of the five contaminated ones had received less than the usually recommended sterilizing dosage of 5×10^6 rads. The only anomalous value is the one capacitor which showed contamination even though it had been exposed to 10^7 rads of gamma radiation, a dosage which normally would have a fair margin of safety. Microorganisms at the center of a capacitor are protected by many layers of metal foil, and although gamma radiation is quite penetrating, the exact dosage at the center of the component cannot be precisely determined, and could have been below 5×10^6 rads. It is the dosage at the internal site where the microorganisms are present; not at the surface of the component that is important.

The six components exposed to dry heat at 149 C for 70 hours showed no contamination. This would be expected since Bruch et al ^{2/} demonstrated that bacterial spores entrapped in solids such as plaster of Paris, asbestos patching cement and various dental materials were killed after 30 hours exposure to dry heat at 120 C (248 F).

Sterilization dosages whether heat or radiation are quite well known, having been worked out in large scale experiments where statistical confidence can be placed on the results. Tests with a few components such as employed in these tests, can spot check such values, but cannot be used to establish them. They are of more value in determining whether sterilization treatments, recommended from other experiments, adversely affect the component reliability, than they are in working out optimum sterilization treatments.

References

1. Phillips, C.R. and R.K. Hoffman. Sterilization of interplanetary vehicles. Science 132:991-995. 1960.
2. Cordaro, J.T. and E.S. Wynne. Sterilization of electronic components of spacecraft. In Transactions of the Seventh Symposium of Ballistic Missile and Space Technology. Vol. 1, pp 73-82. Aerospace Corp., Pasadena, California. Aug 1962.
3. Bruch, C.W., M.G. Koesterer, and M.K. Bruch. Dry-heat sterilization: Its development and application to components of exobiological space probes. Developments in Ind Microbiology, Vol 4, pp 334-342, 1963.

Table I.

Number of Electronic Components Internally Contaminated

Treatment	Electronic Component	No. Contaminated No. Tested
None	Resistor RNR	0/4
	Capacitor CPV08	0/3
	Transistor 2N3250	1/2
Gamma Radiation (10^6 rad)	Resistor RNR	0/2
	Capacitor CPV08	1/2
Gamma Radiation (5×10^6 rad)	Resistor RNR	0/2
	Capacitor CPV08	0/2
Gamma Radiation (10^7 rad)	Resistor RNR	0/2
	Capacitor CPV08	1/2
Neutron Radiation (4×10^{14} fluence)	Transistor 2N3250	2/2
	Transistor 2N3307	1/2
Heat (70 hrs @ 149 C)	Resistor RNR	0/3
	Capacitor CPV08	0/3